Long-term performance of the extended pulsed optical timing system

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The optical timing system of the FERMI facility underwent a significant upgrade to accommodate requests for additional pulsed links for remote lasers or diagnostic stations. Following the successful completion of compliance tests, the long-term performance of the extended system has been recently evaluated through out-of-loop measurements. In the setup each of the two pulsed subsystems, synchronized to the common optical master oscillator, feeds a stabilized fiber optic link. The relative stability between the outputs has been monitored at a remote location. The results achieved and the challenges encountered during the measurements will be discussed.

Introduction

FERMI [1] is a fourth generation light source, a seeded Free Electron Laser (FEL), operating as a user facility in Trieste, Italy. An advanced all-optical timing and synchronization system [2] is implemented as a hybrid architecture, combining pulsed and continuous wave techniques, to provide the reference with femtosecond precision.

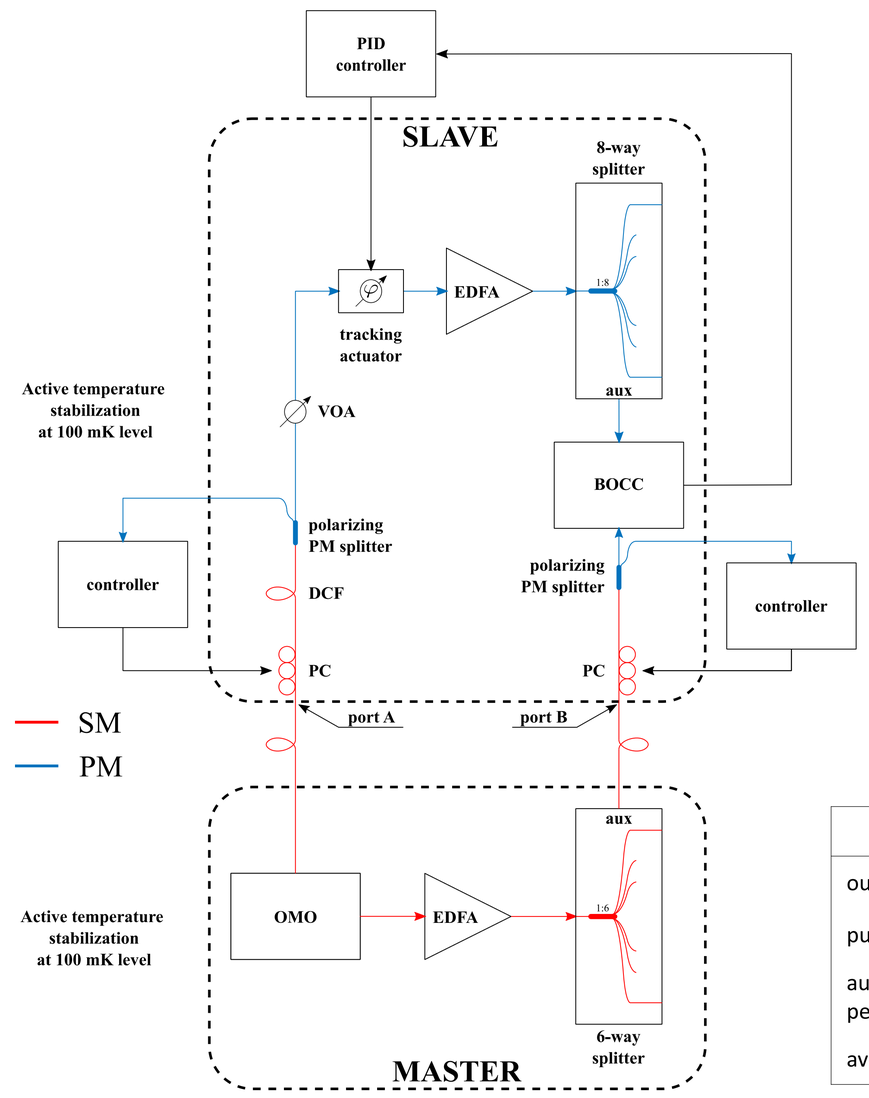
The total number of stabilized pulsed links that can be deployed for the extended system is now fourteen. One of the design constraints was to maintain mechanical and optical compatibility with the link stabilization units installed in the past.

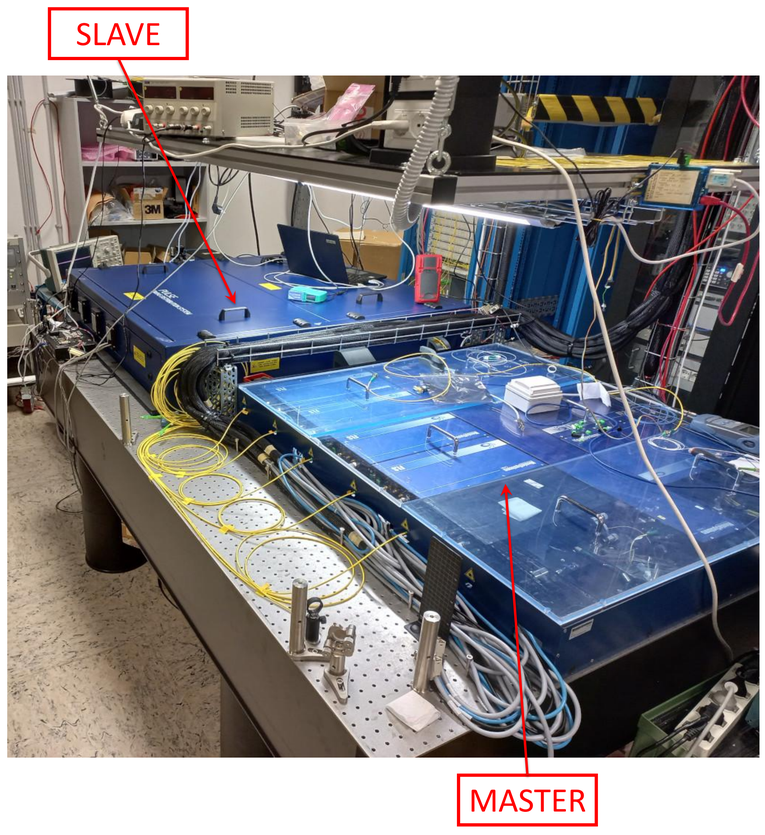
We have implemented [3] a master-slave architecture. The original system is considered the **master** while the extension is the **slave**. The slave is locked to the master to remove residual timing drifts and keep the pulses coming out from the outputs of the master and slave splitters synchronized.

Long-term measurements are the most critical aspects to be verified in a synchronization system:

- ❑ lengthy acquisition time: “fix and try-again” process is tedious, a lot of time is needed to evaluate the effect of a possible improvement;
- ❑ distributed system: many variables can affect the outcome (we have monitored more than 200 attributes during the tests);
- ❑ best results during machine operations: to avoid external influence and exploit a stable environment.

The extended pulsed optical timing system

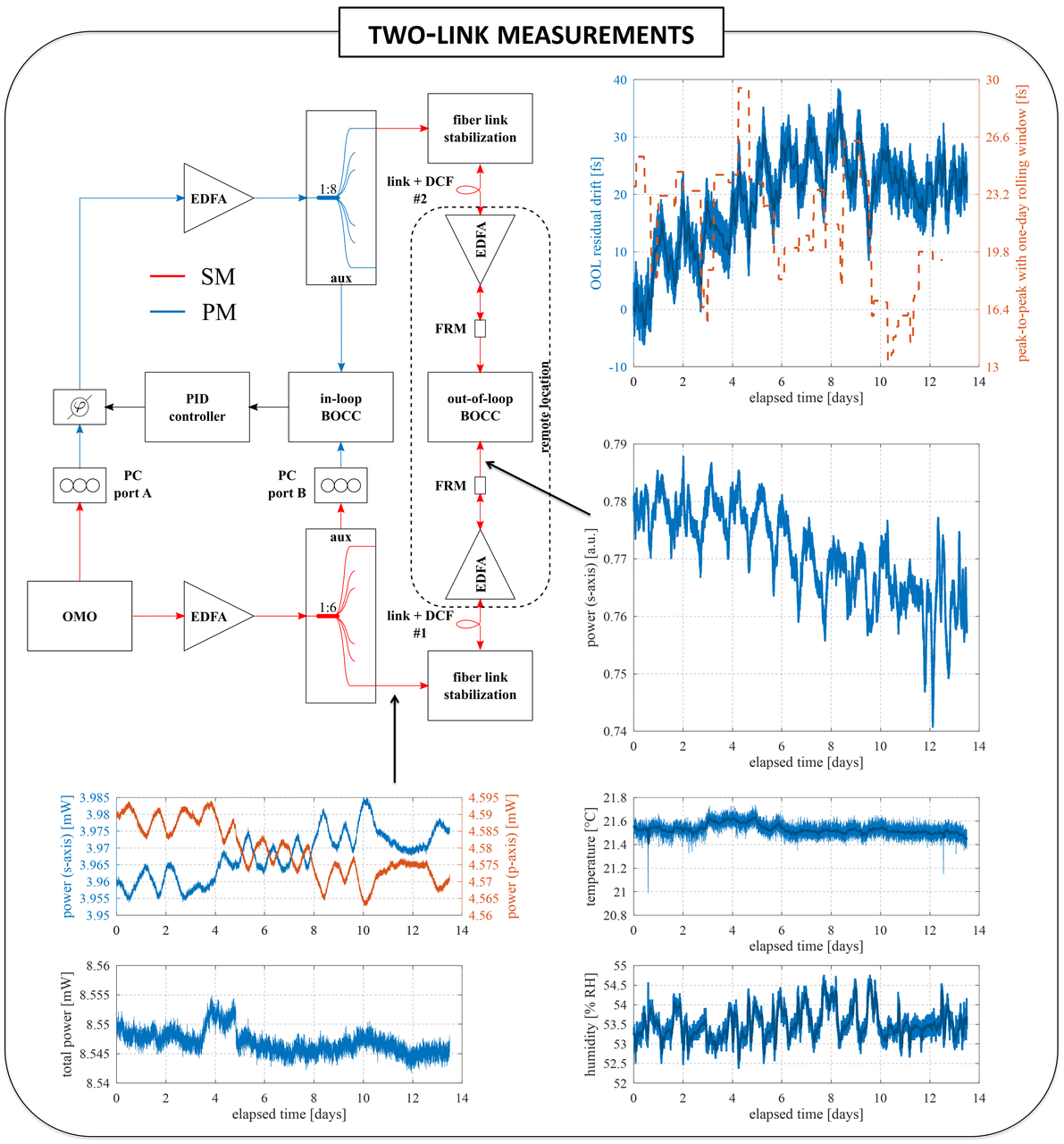




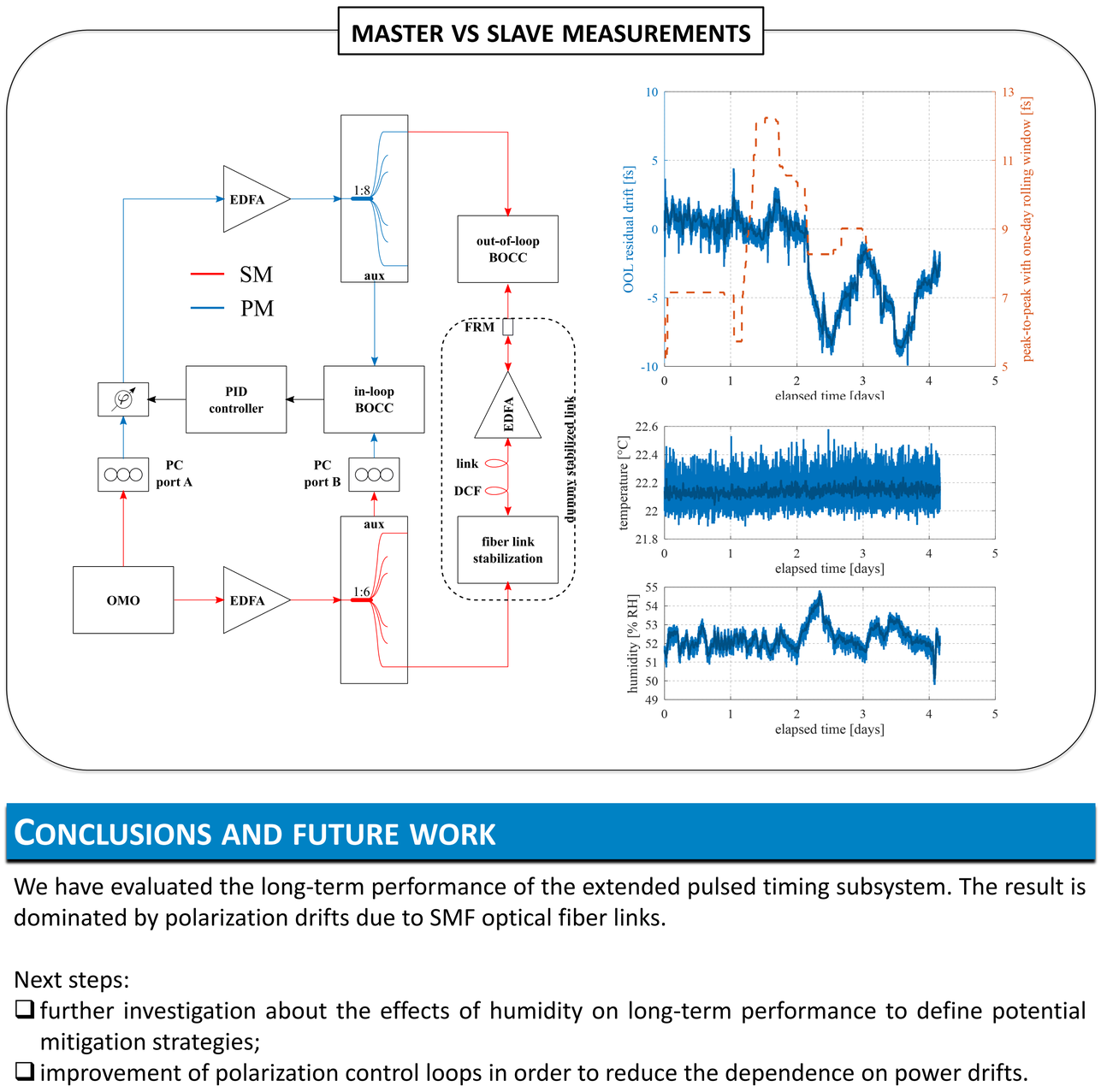
most relevant specifications			
output ports	8	amplitude noise	< 0.1 % RMS [10 Hz - 10 MHz]
pulse duration	< 200 fs FWHM	additive jitter	< 10 fs RMS [10 Hz - 10 MHz]
autocorrelation pedestal height	< 0.15%	splitter stability	< 25 fs p2p over 24-hour interval
average power	> 45 mW	tracker stability	< 25 fs p2p over 24-hour interval

Long-term performance highlights

Two-link measurements



Master vs slave measurements



Conclusions and future work

We have evaluated the long-term performance of the extended pulsed timing subsystem. The result is dominated by polarization drifts due to SMF optical fiber links.

Next steps:

- ❑ further investigation about the effects of humidity on long-term performance to define potential mitigation strategies;
- ❑ improvement of polarization control loops in order to reduce the dependence on power drifts.

REFERENCES

[1] E. Allaria et al., Highly coherent and stable pulses from the FERMI seeded free-electron laser in the extreme ultraviolet

[2] M. Ferianis et al., All-optical femtosecond timing system for the FERMI@Elettra FEL

[3] F. Rossi et al., Installation and commissioning of the pulsed optical timing system extension

[4] P. Cinqugrana et al., The seed laser system of the FERMI free-electron laser: design, performance and near future upgrades

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